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EDWIN DUNKIN, F.R.S., President, in the Chair.

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Walter Claude Johnson, Mem. Inst. C.E., 8 Vanbrugh Park, Blackheath, S.E.;
Richard Wilding, Sunny Bank, Victoria Road, Fulwood, Preston,

were balloted for and duly elected Fellows of the Society.

On the Term of Long Period due to Mars in the Expression for the Longitude of the Moon. By Edmund Neison.

In the last volume of the *Memoirs* (vol. xlviii., Part II. p. 419), there is a paper by M. Gogou, containing a calculation of the value of the term of long period in the expression for the longitude of the Moon, arising from the disturbing action of *Mars*, together with a lengthy criticism of my own merely provisional calculations published in the *Monthly Notices* for November 1877 (vol. xxxviii. pp. 49–53).

M. Gogou finds a result differing much from mine, and this difference he considers due to three things:

I. Because I employ strictly undisturbed elliptic coordinates of the Moon instead of coordinates partially modified by the action of the Sun.

II. Because there are errors in the expression assigned by me to the disturbing function.

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III. Because I have omitted a number of small terms which have been retained by him.

Practically the whole *Memoir* is devoted to supplying these deficiencies, so some comment on my part seems called for.

It should be borne in mind that the calculation so elaborately criticised by M. Gogou in his eighteen pages of the *Memoirs* was a mere first provisional calculation occupying just three pages of the *Notices*, a calculation stated at the time to be a mere provisional approximation needing revision and extension, as well as the inclusion of the higher powers of the disturbing forces.

My reply to M. Gogou's criticism is short and direct.

I. I employed the strictly undisturbed values of the elliptic coordinates of the Moon, because, as expressly stated, my calculation was confined to the part of the co-efficient depending on the first power of the disturbing forces.

By introducing a few terms nominally independent of m, M. Gogou has vitiated the accuracy of his results, for these terms, though independent, by a mere convention, of m, do all the same depend on the disturbing power of the Sun; and if the effects of the disturbing action of the Sun is to be introduced at all, it must be introduced throughout and not only in part, and must include the terms explicitly depending on m as well as the terms which merely implicitly depend on m.

II. M. Gogou shows that there are errors in the expression assigned by me to the disturbing function on page 52 of my original note. This is true; in two places a is printed for a^2, and in one case a is printed for $2a$. But a glance at the previous steps ought to have shown M. Gogou that these are purely printer's errors of not the slightest importance, as they do not exist in the calculations themselves. The very symmetry of the previous expansions might have shown this to M. Gogou, and thus saved him compiling an elaborate memoir to rectify some printer's omissions.

III. The reason why I omitted the terms forming M. Gogou's expression R., is expressly stated in my original note, because they were so small as to be insensible (p. 51, lines 10–12). All that M. Gogou has done has been to show by an elaborate calculation that I am perfectly correct—they are absolutely insensible. I did not deem a calculation necessary, as the result was so obvious.

It is true, that according to M. Gogou, the more important portion of the co-efficient, that calculated by me, yields results no larger than this other. But even were this really the case, it does not show, as M. Gogou seems to think, that I ought to have elaborately calculated both, but merely that I need not have calculated either.

It is not too much to say that nine-tenths of this memoir of M. Gogou's is devoted to the elaborate calculation of small terms which could not possibly be of the smallest importance, being, as

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already pointed out by me, so small as to be completely insensible. And all that this part of M. Gogou's memoir does is to prove the correctness of this statement of mine. The remainder consist merely of a somewhat more detailed expression for the terms calculated by me, but with this difference, as pointed out in my note in the *Monthly Notices* for March 1885 (vol. xlv. pp. 326–328), that my calculations are more complete than those of M. Gogou. This note in the *Monthly Notices* for March, deals with the only real issue between us, and the entire memoir of M. Gogou is utterly beside the question, being devoted to the elaborate calculation of a mass of small terms, which we both agree in finding completely insensible.

My own memoir on this subject, like all the rest of my scientific work, was brought to a complete standstill by long severe illness throughout the entire summer; and though slowly recovering, I fear their publication will all be seriously delayed, as it will be some time yet ere I can return to the mathematical work.

The Observatory, Natal:
1885, *Nov.* 9.

Comparison of Groombridge's and Struve's Right Ascensions of Close Circumpolar Stars. By Truman Henry Safford.

Groombridge's Catalogue of Circumpolar Stars is so important, and in many respects excellent, that its positions ought to be improved as far as possible. The attempt has been made to do this by the application of systematic corrections; but those in Right Ascension are hardly well enough known for the region immediately about the North Pole.

The correction usually employed is Argelander's

$$+0^{\mathrm{s}}{\cdot}06 + 0^{\circ}{\cdot}12 \tan \delta.$$

which is derived from the previous investigations of Struve and Fedorenko, combined with his own.

Struve's hypothesis is that Groombridge's meridian mark was about 3″ in error; but the comparisons which I give in the present paper will show that this may not be altogether certain, at least for the earlier period (1806–1809), when Groombridge was especially observing the closer polars.

Within 10° of the Pole there are few stars with which comparison has been made between Groombridge and later observers. In order to fill this gap, I have compared his catalogue with the Dorpat Right Ascensions observed by W. Struve in 1814 and 1815. In this I have employed only Struve's Catalogus I., which contains the closer stars, and have confined myself to the region north of +70°. The results are as follows:—

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ZONE +86° TO +90°.

No. Groombridge.	Polar Distance.	Δα Struve-Groombridge.	Δα cos δ.
	°	s	s
144	2·0	− 1·82	−0·06
235	1·7	+ 0·40	+0·01
642	4·0	− 1·14	−0·08
1119	0·9	−12·05	−0·20
1141	2·7	− 3·73	−0·18
1850	3·4	+ 1·09	+0·06
1871	2·5	− 0·67	−0·03
1884	1·3	− 0·93	−0·02
2006	1·4	+ 3·29	+0·08
2065	1·5	+11·8	+0·31
2099	3·4	+ 3·71	+0·22
2210	3·3	+ 3·88	+0·22
2283	2·1	+ 1·63	+0·06
2628	3·4	+ 0·07	0·00
2667	3·1	+ 0·45	+0·02
3308	1·3	+ 1·83	+0·04
3548	3·7	+ 0·88	+0·06
4101	3·7	− 0·35	−0·02

ZONE +83° TO +86°.

No. Groombridge.	Polar Distance.	Δα Struve-Groombridge.	Δα cos δ.
	°	s	s
67	4·7	+0·79	+0·06
177	4·8	+0·20	+0·02
595	5·8	+2·49	+0·25
750	5·0	+0·47	+0·04
766	6·7	+0·44	+0·05
944	4·9	−0·83	−0·07
956	4·8	+2·63	+0·22
1359	5·4	−5·56	−0·53
1418	4·3	−5·72	−0·43
1620	4·8	+0·47	+0·04
1633	6·5	−0·33	−0·04
1889	5·3	+2·91	+0·27
1937	5·6	+1·15	+0·11
1940	5·6	+1·76	+0·17
2007	4·3	+1·12	+0·09

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No. Groombridge.	Polar Distance.	Δα Struve-Groombridge.	Δα cos δ.
	°	s	s
2063	6·3	+1·24	+0·14
2196	6·7	+1·25	+0·15
2213	5·3	+1·98	+0·16
2315	6·5	+0·83	+0·09
2476	6·6	+0·56	+0·06
2548	6·6	−2·10	−0·24
3501	6·5	−0·30	−0·03
3820	4·8	+0·33	+0·03
3824	4·7	−0·47	−0·04
3970	6·6	−0·45	−0·05
4193	4·3	+0·20	+0·02

Zone 80° to 83°.

No. Groombridge.	Polar Distance.	Δα Struve-Groombridge.	Δα cos δ.
	°	s	s
424	9·6	+0·94	+0·16
426	9·4	+1·28	+0·21
506	9·2	−0·03	0·00
527	9·4	+0·67	+0·11
580	9·3	+0·58	+0·09
746	9·8	−0·05	−0·01
774	7·1	+0·43	+0·05
779	9·6	+0·47	+0·08
785	9·5	+0·52	+0·09
856	9·1	+0·99	+0·16
1255	8·4	−1·17	−0·17
1259	7·3	+0·54	+0·07
1278	8·8	−0·49	−0·07
1339	9·3	−0·50	−0·08
1355	9·7	+0·56	+0·09
1391	7·0	−0·85	−0·10
1431	7·1	−1·81	−0·22
1452	9·3	−0·56	−0·09
1463	9·3	−0·83	−0·13
1480	8·5	−0·08	−0·01
1537	7·9	−1·46	−0·20
1643	8·6	−0·85	−0·13
1662	8·6	−0·36	−0·05
1778	7·9	+1·01	+0·14

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No. Groombridge.	Polar Distance.	Δα Struve-Groombridge.	Δα cos δ.
	°	s	s
1782	7·9	−0·07	−0·01
1845	8·1	+1·86	+0·26
1858	7·3	−0·13	−0·02
1909	8·7	+1·31	+0·20
1927	8·4	+1·34	+0·19
1977	8·5	+0·15	+0·02
2037	8·7	+0·05	+0·01
2071	8·3	+0·80	+0·12
2275	9·0	+1·93	+0·30
2276	9·0	+2·06	+0·32
2422	7·7	+0·29	+0·04
2456	9·7	+0·23	+0·04
3268	9·2	+0·40	+0·06
3276	9·2	+0·43	+0·07
3277	9·6	+0·33	+0·05
3370	8·2	+0·85	+0·12
3707	8·4	+0·23	+0·03
3709	8·4	+0·79	+0·12
3887	9·6	−0·10	−0·03
3928	7·8	−0·30	−0·04

Zone 70° to 80°.

No. Groombridge.	Polar Distance.	Δα Struve-Groombridge.	Δα cos δ.
	°	s	s
616	13·0	+0·53	+0·12
919	11·0	+0·71	+0·14
966	15·1	+0·69	+0·18
1217	12·8	+0·63	+0·14
1562	10·0	−0·71	−0·12
1650	13·3	+0·98	+0·23
1859	11·4	+0·58	+0·11
2094	11·6	+0·10	+0·02
2130	13·5	+0·21	+0·05
2172	15·1	+0·65	+0·17
2228	17·5	−0·09	−0·03
2236	17·5	+0·55	+0·17
2268	12·0	+1·46	+0·31
2294	11·6	+1·39	+0·28

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No. Groombridge.	Polar Distance.	$\Delta\alpha$ Struve-Groombridge.	$\Delta\alpha \cos\delta$.
	°	s	s
2334	13·7	+0·28	+0·07
2336	14·3	−0·69	−0·17
2349	13·8	+0·67	+0·16
2475	17·8	0·00	0·00
2477	17·8	−0·06	−0·02
2546	10·0	[−4·92]	
2547	10·0	[−4·98]	
2726	14·8	+0·08	+0·02
2930	16·0	+0·43	+0·12
3148	12·9	+0·43	+0·10
3373	10·1	−1·16	−0·20
3419	12·6	+0·16	+0·04
3508	14·4	−0·75	−0·19
3511	10·3	+1·74	+0·31
3809	12·2	−0·71	−0·15
3831	12·1	−0·82	−0·17
3834	14·7	−0·74	−0·19
4122	13·4	−0·04	−0·01

The stars connected by braces are components of pretty close doubles; the comparison has been made by using Groombridge's precessions reduced to Struve; the secular variations of the Radcliffe Catalogue, and the best proper motions attainable, either those of the *Fundamental Catalogue* of the *Berliner Jahrbuch*, those of Albrecht, or my own published or unpublished results. No error of any consequence has arisen from the occasional use of rather rough values, as the interval is everywhere less than nine years.

It will be seen on taking the means that the values of $\Delta\alpha \cos\delta$ vary but little with the declination, but are subject to rather large casual errors.

The mean value of $\Delta\alpha \cos\delta$ is $= +0^{s}{\cdot}034 \pm 0^{s}{\cdot}009$, and the probable error of the result from one star $= \pm 0^{s}{\cdot}093$ by sums of errors.

This is too large a quantity to be accounted for by the ordinary errors of observation. A liberal allowance for them in Struve's cases is $\pm 0^{s}{\cdot}03$ to $\pm 0^{s}{\cdot}04$, leaving at least $\pm 0^{s}{\cdot}084 = \sqrt{(0{\cdot}093)^2 - (0{\cdot}04)^2}$ for Groombridge. In one case, the double star 40 and 41 *Draconis*, the discrepancy arises from a mistake in Groombridge's reduction, as both stars are largely in error in his catalogue; and the stars *Groombridge* 1359 and 1418 are also suspicious; in both these cases Struve has three observations, and is confirmed by Schwerd and later authorities.

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A small part of the visible periodicity is due to the use of an erroneous nutation-constant; but I think there is but little doubt that the main cause of discrepancy is instrumental error. Groombridge's meridian mark was rather too near—about half a mile, if the map of London, contained in Baedeker's guide-book, is trustworthy—and a previous investigation of Maskelyne's and Pond's observations has shown me that a polar deviation (Bessel's n) of $\pm 1''$ is not altogether to be avoided when the instrument is adjusted to the Meridian from time to time, and left for days to its own motions, without allowing for azimuth and level error in the modern fashion.

Singularly enough, the constant correction here indicated ($+0^{s}\cdot034 \sec \delta$ or $+0^{s}\cdot034 \tan \delta$, very nearly the same thing) is but little more than would be derived from the observations of *Polaris* between June 23, 1806, and April 27, 1807, as given on p. xiii. of the Catalogue. The mean of the six double transits gives—

Excess of lower—upper culminations $= +2^{s}\cdot05$, and this multiplied by one-half the cotangent of the star's declination gives $+0^{s}\cdot03$ for the value of Bessel's n, or the polar deviation.

But these northern stars were mainly observed in 1806, 1807, and 1808. There is some difference between Struve's observations of 1814 and 1815, and those made later by himself and Argelander, which seem to be of the nature of personal equation. The comparison of all Groombridge's stars below 80°, which can be found in the later catalogues mentioned, gives $+0^{s}\cdot12$ for the coefficient of $\tan \delta$, instead of $+0^{s}\cdot035$. I do not think that any definite conclusion can be arrived at as to the real meaning of this term until it shall be possible to subject Groombridge's Right Ascensions to a careful revision with respect to signs of instrumental deviation.

This should not be a difficult task, employing his manuscripts, but would be greatly aided if their main portions were printed, as the original observations of Piazzi have been, so that any who were desirous to study them could have the opportunity.

There is no doubt, I think, that Groombridge's work deserves nearly as much attention in future ages as does Bradley's, allowance being made for the limited region in which he chiefly laboured; and I am quite sure that a careful revision of his results would repay the trouble spent on it in a great variety of directions.

At present it is almost impossible to obtain absolutely definitive values for the proper motions of the closer polars without very arbitrary assumptions as to the weight and systematic correction of Groombridge; and even the best ephemerides of these stars are in places quite uncertain, owing to the lack of trustworthy proper motions.

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On the Reduction of Bessel's Precessions to those of Struve.

By A. A. Rambaut.

(*Communicated by Prof. R. S. Ball.*)

In the *Monthly Notices*, vol. xxxix. p. 364, Prof. Krueger has given a formula for reducing the annual precessions of Bessel to those of Struve, and Prof. Auwers has given tables in the *Fundamental Catalogue* containing corrections to Bessel's secular variations. Prof. Krueger's tables for the precessions in Right Ascension I have merely transcribed here, in order to have them along with the other tables, but I have put the corrections to the precessions in Declination in what appears to me a more convenient form. Prof. Auwers' tables are for reducing Bessel's secular variations for the year 1860, to those of Struve for 1875, whereas the object of this paper is to reduce the precessions, and secular variations of the precessions, according to Bessel, for any year, to their values as derived from Struve's constants for the same year. That this is not quite the same thing will appear from a comparison of the tables which follow with those of Prof. Auwers.

Let capital letters denote the values of the constants at the beginning of the century, and let those with B subscript refer to Bessel, and those with S subscript to Struve.

Then

$$m_B = M_B + m'_B . t = 46''.04367 + 0''.0003086450 \cdot t$$
$$m_S = M_S + m'_S . t = 46.0623 \quad + 0.0002849 . t$$
$$n_B = N_B + n'_B . t = 20.05957 - 0.0000970204 . t$$
$$n_S = N_S + n'_S . t = 20.0607 \quad - 0.0000863 . t$$

Then the annual precession according to Bessel (P_B).

$$= \tfrac{1}{15}\, m_B + \tfrac{1}{15}\, n_B \tan \delta \sin \alpha$$

And

$$P_S = \tfrac{1}{15}\, m_S + \tfrac{1}{15}\, n_S \tan \delta \sin \alpha$$

therefore

$$P_S - P_B = \tfrac{1}{15} . \frac{m_S n_B - m_B n_S}{n_B} + \frac{n_S - n_B}{n_B}\, P_B = k + l P_B .$$

The factor l being at its greatest equal to 0.00010823, it is sufficient to take P_B to two places of decimals in this equation to obtain the result correct to five.

The values of k and l for every tenth year during the century, which are given in Table I., are taken from Prof. Krueger's paper in the *Monthly Notices*, correcting an evident misprint which has occurred in the latter.

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Again, Bessel's precession in declination (Q_B)

$$Q_B = n_B \cos \alpha, \text{ and } Q_S = n_S \cos \alpha,$$

whence

$$Q_S - Q_B = (n_S - n_B) \cos \alpha.$$

The values of this are given in Table II. for every tenth year during the century, and for every hour of Right Ascension in units of the fourth decimal. They are always of the same sign as Q_B.

The secular variation in α is

$$P' = \tfrac{100}{15}\left(m' + \frac{n^2}{2K} \sin 2\alpha\right) + \tfrac{100}{15}\left(n' \sin \alpha + \frac{mn}{K} \cos \alpha\right) \tan \delta$$
$$+ \tfrac{100}{15} \frac{n^2}{K} \sin 2\alpha \tan^2 \delta,$$

where

$$K = 206265,$$

or

$$P' = A + B \tan \delta + C \tan^2 \delta.$$

Therefore

$$P'_S - P'_B = (A_S - A_B) + (B_S - B_B) \tan \delta + (C_S - C_B) \tan^2 \delta.$$

Also the secular variation in δ is

$$Q' = 100\left(n \cos \alpha - \frac{mn}{K} \sin \alpha\right) - \frac{100}{K} n^2 \sin^2 \alpha \tan \delta = A' + B' \tan \delta,$$

and therefore

$$Q'_S - Q'_B = (A'_S - A'_B) + (B'_S - B'_B) \tan \delta.$$

We have

$$A_S - A_B = \tfrac{100}{15}\left\{ m'_S - m'_B + \frac{1}{2K} (n_S{}^2 - n_B{}^2) \sin 2\alpha \right\}.$$

From the values given above we find

$$\tfrac{100}{15}(m'_S - m'_B) = -0{\cdot}0001583.$$

Also

$$\frac{100}{30K}\left\{ n_S{}^2 - n_B{}^2 \right\} = \frac{100}{30K}\left\{ N_S{}^2 - N_B{}^2 + 2(N_S n'_S - N_B n'_B)t + \left(n'_S{}^2 - n'_B{}^2\right)t^2 \right\}$$

The last term in this is quite inappreciable, and we find

$$\frac{100}{30K}\left(N_S{}^2 - N_B{}^2\right) = +0^s{\cdot}0000006,$$

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and

$$\frac{100}{15\mathrm{K}}\left(\mathrm{N_S}\,n'_\mathrm{S}-\mathrm{N_B}\,n'_\mathrm{B}\right)=+0{\cdot}0000000069,$$

whence during the century

$$\mathrm{A_S}-\mathrm{A_B}=-0^{\mathrm{s}}{\cdot}000158.$$

Again

$$\mathrm{A'_S}-\mathrm{A'_B}=100\left\{(n'_\mathrm{S}-n'_\mathrm{B})\cos\alpha-\frac{m_\mathrm{S}\,n_\mathrm{S}-m_\mathrm{B}\,n_\mathrm{B}}{\mathrm{K}}\sin\alpha\right\},$$

and we have

$$100(n'_\mathrm{S}-n'_\mathrm{B})=+0{\cdot}00107.$$

Also

$$\frac{100}{\mathrm{K}}\left\{m_\mathrm{S}n_\mathrm{S}-m_\mathrm{B}n_\mathrm{B}\right\}=\frac{100}{\mathrm{K}}\left\{\mathrm{M_SN_S}-\mathrm{M_BN_B})+(m'_\mathrm{S}\mathrm{N_S}-m'_\mathrm{B}\mathrm{N_B}\right.$$
$$\left.+\ \mathrm{M_S}n'_\mathrm{S}-\mathrm{M_B}n'_\mathrm{B})t+(m'_\mathrm{S}n'_\mathrm{S}-m'_\mathrm{B}n'_\mathrm{B})t^2\right\}.$$

The third term in this is also inappreciable, and we find

$$m'_\mathrm{S}\mathrm{N_S}-m'_\mathrm{B}\mathrm{N_B}=-0{\cdot}0004759923,$$

and

$$\mathrm{M_S}n'_\mathrm{S}-\mathrm{M_B}n'_\mathrm{B}=+0{\cdot}0004919990,$$

and therefore

$$m'_\mathrm{S}\mathrm{N_S}-m'_\mathrm{B}\mathrm{N_B}+\mathrm{M_S}n'_\mathrm{S}-\mathrm{M_B}n'_\mathrm{B}=+0{\cdot}0000160067,$$

whence it is clear that the coefficient of sin α in the value of

$$\mathrm{A'_S}-\mathrm{A'_B}\ \text{is}\ \frac{100}{\mathrm{K}}\left(\mathrm{M_SN_S}-\mathrm{M_BN_B}\right)=+0{\cdot}00020642.$$

Thus we have

$$\mathrm{A'_S}-\mathrm{A'_B}=(10{\cdot}7\cos\alpha-2{\cdot}064\sin\alpha)$$

in units of the fourth decimal.

The values of this correction for every hour of Right Ascension are given in Table III.

The value of $\mathrm{A'_S}-\mathrm{A'_B}$ in seconds of arc for any value of α is fifteen times that of $\mathrm{B_S}-\mathrm{B_B}$ in seconds of time for $\alpha+6^{\mathrm{h}}$. Thus we obtain the correction to $\mathrm{B_B}$ from the following table, which is immediately deducible from Table III.

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h	$B_S - B_B$	h	h	$B_S - B_B$	h	h	$B_S - B_B$	h
0	+1·4	12	4	+6·9	16	8	+5·5	20
1	+3·2	13	5	+7·2	17	9	+4·1	21
2	+4·8	14	6	+7·1	18	10	+2·4	22
3	+6·0	15	7	+6·5	19	11	+0·5	23
						12	−1·4	24

Between 12^h and 24^h take the correction with an opposite sign. The correction is given in units of the fifth decimal. Table IV. gives the value of this multiplied by tan δ.

It remains to find the values of $C_S - C_B$ and of $B'_S - B'_B$. We have

$$C_S - C_B = \frac{100}{15K}\left(n_S^2 - n_B^2\right) \sin 2\alpha$$

$$= \left\{ + 0^s{\cdot}0000012 + 0^s{\cdot}0000000138 \,.\, t \right\} \sin 2\alpha.$$

Although this term is very small, yet being multiplied by tan^2 δ, it has an effect on stars whose declinations exceed 50°. In Table V. are given the values of the coefficient of $\sin 2\alpha$ for every tenth year, and in Table VI. the values of $\sin 2\alpha \tan^2 \delta$. The product of these two quantities, along with the number taken from Table IV., and the constant $-0^s{\cdot}000158$, gives the whole correction to the secular variation of the precession in α.

Again

$$B'_S - B'_B = -\frac{100}{K}\left(n_S^2 - n_B^2\right) \sin^2 \alpha$$

$$= -(0''{\cdot}000018 + 0''{\cdot}000000207 \,.\, t) \sin^2 \alpha,$$

this multiplied by tan δ, if $t = 100$ and $\alpha = 6^h$, does not amount to $0''{\cdot}0001$, as long as δ is less than 69°, and as its greatest value—for 80°—within the limits of these tables is $0''{\cdot}00022$, it may be safely neglected. We have thus the whole correction to Q_B from Table III. in units of fourth decimal.

If, however, it be thought necessary to correct for this term, the numerical coefficient is given in Table VII. for every twentieth year during the century, and the corresponding factor in Table VIII. The whole correction, then, to the secular variation of the precession in δ, in units of the fourth decimal, is the number taken from Table III., along with the product of those taken from Tables VII. and VIII.

Example—

$$\alpha = 20^h\ 24^m\ 27^s{\cdot}5, \qquad \delta = -10^\circ\ 20'\ 41''$$

for 1855.

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The annual precession in α with Bessel's constants $= + 3^{s}\cdot 26785$

,, ,, δ ,, ,, $= +11''\cdot 8200$

Secular variation of the precesssion in α $= -0^{s}\cdot 00785$

,, ,, ,, δ $= +0''\cdot 3793$

From Table I. we find for 1855

$k = 0\cdot 000895$ and $l = 0\cdot 0000842$.

We have then

$$\begin{aligned} P_B &= +\ 3\cdot 26785 \\ 3\cdot 27 \times 0\cdot 0000842 &= 275 \\ k &= 895 \\ \hline P_S &= +\ 3\cdot 26902 \end{aligned}$$

Also

$$\begin{aligned} Q_B &= +11\cdot 8200 \\ \text{Correction from Table III.} &= 10 \\ \hline Q_S &= +11\cdot 8210 \end{aligned}$$

Again,

$$\begin{aligned} P'_B &= -\ 0\cdot 00785 \\ \text{Correction from Table IV.} &= +09 \\ \text{,, ,, Tables V. and VI.} &= 00 \\ A_S - A_B &= -158 \\ \hline &\ -\ 0\cdot 00800 \end{aligned}$$

And, finally,

$$\begin{aligned} Q'_B &= +\ 0\cdot 3793 \\ \text{Correction from Table III.} &= +79 \\ \hline Q'_S &= +\ 0\cdot 3801 \end{aligned}$$

In order to show the difference between these tables and those of Prof. Auwers, in the *Fundamental Catalogue*, let us compare the secular variations in α of a star for which $\alpha = 3^{h}$ and $\delta = 78°$ for 1875.

By direct calculation we find

$P'_S = +0^{s}\cdot 393557$ and $P'_B = +0^{s}\cdot 393376$.

$$\begin{aligned} \text{The correction from Table IV.} &= +28\cdot 3 \\ \text{,, from Tables V. and VI.} &= +\ \ 5\cdot 1 \\ A_S - A_B &= -15\cdot 8 \\ \hline &\ +17\cdot 6 \end{aligned}$$

Which would give $P'_S = 0^{s}\cdot 393552$. Prof. Auwers' correction is 14·2, which would make $P'_S = 0^{s}\cdot 393518$.

TABLE I.

	k	*l*		*k*	*l*		*k*	*l*
1800	+0·00107	+0·00005484	1840	+0·00094	+0·00007619	1880	+0·00081	+0·00009755
1810	0·00104	0·00006018	1850	0·00091	0·00008153	1890	0·00078	0·00010289
1820	0·00101	0·00006551	1860	0·00088	0·00008687	1900	0·00075	0·00010823
1830	0·00098	0·00007085	1870	0·00085	0·00009221			

TABLE II.

α	1800.	1810.	1820.	1830.	1840.	1850.	1860.	1870.	1880.	1890.	1900.	α
0^h or 24^h	11·3	12·4	13·4	14·5	15·6	16·7	17·7	18·8	19·9	20·9	22·0	12^h or 12^h
1 ,, 23	10·9	12·0	12·9	14·0	15·1	16·1	17·1	18·2	19·2	20·2	21·3	13 ,, 11
2 ,, 22	9·8	10·7	11·6	12·6	13·5	14·5	15·3	16·3	17·2	18·1	19·1	14 ,, 10
3 ,, 21	8·0	8·8	9·5	10·3	11·0	11·8	12·5	13·3	14·1	14·8	15·6	15 ,, 9
4 ,, 20	5·6	6·2	6·7	7·2	7·8	8·3	8·8	9·4	10·0	10·5	11·0	16 ,, 8
5 ,, 19	2·9	3·2	3·5	3·8	4·0	4·3	4·6	4·9	5·2	5·4	5·7	17 ,, 7
6 ,, 18	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	18 ,, 6

TABLE III.

α	Correction.	α	α	Correction.	α	α	Correction.	α	α	Correction.	α
0^h	+10·7	12^h	4^h	+3·6	16^h	7^h	−4·8	19^h	10^h	−10·3	22^h
1	+ 9·8	13	5	+0·8	17	8	−7·1	20	11	−10·9	23
2	+ 8·2	14	6	−2·1	18	9	−9·0	21	12	−10·7	24
3	+ 6·1	15									

Betweeen 12^h and 24^h take the correction with an opposite sign.

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TABLE IV.

		0°	10°	20°	30°	40°	50°	60°	65°	70°	72°	74°	76°	78°	80°		
0h	+	0·0	0·2	0·5	0·8	1·2	1·6	2·4	2·9	3·8	4·	4·8	5·5	6·5	7·8	–	12h
1	+	0·0	0·6	1·2	1·8	2·7	3·8	5·5	6·8	8·7	9·8	11	12·7	14·9	18·0	–	13
2	+	0·0	0·8	1·7	2·8	4·0	5·7	8·2	10·2	13·1	14·6	16·6	19·1	22·4	27·0	–	14
3	+	0·0	1·1	2·2	3·5	5·1	7·2	10·4	12·9	16·5	18·5	21·0	24·1	28·3	34·1	–	15
4	+	0·0	1·2	2·5	4·0	5·8	8·2	11·9	14·7	18·9	21·2	24·0	27·5	32·3	39·0	–	16
5	+	0·0	1·3	2·6	4·2	6·1	8·6	12·6	15·5	19·9	22·3	25·3	29·1	34·0	41·1	–	17
6	+	0·0	1·3	2·6	4·1	6·0	8·5	12·4	15·3	19·6	22·0	24·9	28·6	33·5	40·4	–	18
7	+	0·0	1·1	2·4	3·8	5·5	7·8	11·3	14·0	18·0	20·1	22·8	26·2	30·7	37·1	–	19
8	+	0·0	1·0	2·0	3·2	4·6	6·5	9·5	11·8	15·1	16·9	19·2	22·0	25·8	31·1	–	20
9	+	0·0	0·7	1·5	2·4	3·4	4·8	7·1	8·7	11·2	12·5	14·2	16·3	19·1	23·1	–	21
10	+	0·0	0·4	0·9	1·4	2·0	2·8	4·1	5·1	6·5	7·3	8·3	9·5	11·1	13·4	–	22
11	+	0·0	0·1	0·2	0·3	0·4	0·6	0·9	1·1	1·4	1·6	1·8	2·1	2·4	3·0	–	23
12	–	0·0	0·2	0·5	0·8	1·2	1·6	2·4	2·9	3·8	4·2	4·8	5·5	6·5	7·8	+	24

The signs in the second column are for North, and those in the second last column for South Declinations and Right Ascensions between 0h and 12h. Between 12h and 24h take the correction with an opposite sign.

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TABLE V.

1800	0·12	1840	0·18	1880	0·23
1810	0·13	1850	0·19	1890	0·24
1820	0·15	1860	0·20	1900	0·26
1830	0·16	1870	0·22		

Units of fifth decimal.

TABLE VI.

h	m	55°	60°	64°	68°	70°	72°	74°	76°	78°	80°
0	0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0
	30	0·5	0·8	1·1	1·6	2·0	2·5	3·2	4·2	5·7	8·3
1	0	1·0	1·5	2·1	3·1	3·8	4·7	6·1	8·0	11·0	16·1
	30	1·4	2·1	3·0	4·3	5·3	6·7	8·6	11·4	15·6	22·7
2	0	1·8	2·6	3·6	5·3	6·6	8·2	10·6	13·9	19·1	27·8
	30	2·0	2·9	4·1	5·9	7·3	9·2	11·8	15·3	21·4	32·0
3	0	2·0	3·0	4·2	6·1	7·6	9·5	12·2	16·1	22·1	32·1

The correction for $6^h - \alpha = +$ the correction for α.
„ „ „ $6 + \alpha = -$ „ „ „ „
„ „ „ $12 + \alpha = +$ „ „ „ „

TABLE VII.

1800	0·18	1840	0·26	1880	0·35
1820	0·22	1860	0·31	1900	0·39

TABLE VIII.

	55°	60°	65°	70°	75°	80°	
0^h or 24^h	0·0	0·0	0·0	0·0	0·0	0·0	12^h or 12^h
1 „ 23	0·1	0·1	0·1	0·2	0·2	0·4	11 „ 13
2 „ 22	0·4	0·4	0·5	0·7	0·9	1·4	10 „ 14
3 „ 21	0·7	0·9	1·1	1·4	1·9	2·8	9 „ 15
4 „ 20	1·1	1·3	1·6	2·1	2·8	4·2	8 „ 16
5 „ 19	1·3	1·6	2·0	2·6	3·5	5·3	7 „ 17
6 „ 18	1·4	1·7	2·2	2·8	3·7	5·7	6 „ 18

For North Declinations the factor is negative, and positive for South.

Dunsink:
1885, *Dec.* 10.

Observations of Double Stars at Windsor, New South Wales.

By John Tebbutt.

The accompanying table contains the results of all the double-star observations made by me to the present date. The 4½-inch Equatorial was employed throughout, but it was not driven by clockwork. The steadiness and uniform motion of the slow motion arrangement in Right Ascension were very satisfactory. The greatest difficulty in the work of observation consisted in the measurement of distances when the position angle approached 90° or 270°, but it will be seen that these conditions seldom occurred.